Art. VII.—*Notes on the Dolodrook Serpentine Area and the Mt. Wellington Rhyolites, North Gippsland.*

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(With Plate XI.).

[Read 14th May, 1908].

I.—*Introduction.*

The following remarks deal with some unfinished observations made in the vicinity of Mt. Wellington, North Gippsland. They have been collected during the past four years on short vacation excursions made to this region. As the writer is leaving the State for an indefinite period, it is thought advisable to record the more important features noted, and at the same time to draw attention to problems which are still unsolved.

II.—*Position and Access.*

The district examined lies in the vicinity of Mt. Wellington, and occupies a broad belt of rough mountainous country to the north of the plains of Maffra and Heyfield.

Three routes are available for entry from the Gippsland plains, each following an important valley, namely, those of the Macallister, the Avon or the Wonnangatta rivers. No roads exist, only indifferent pack-tracks are available, and sometimes not even these.

The Macallister route is the only one familiar to the writer, for, as it provides the readiest means of approaching Mt. Wellington, it has always been adopted. Heyfield is the nearest railway town, and thence the road is followed to Glenmaggie, about eight miles distant. These two places afford opportunities for obtaining provisions, and a supply sufficient to last till the return must be taken, for the district is almost unsettled.

Mt. Wellington can be reached with pack horses in about three days from Heyfield, and the Serpentine area in about two from the same place. The Macallister is followed as far as its junction with a tributary, the Wellington river, then the latter valley as far as the western foot of Mt. Wellington. At the Barrier Creek junction a blazed cattle track follows a long spur which leads up to the Wellington snow-plain.

III. *Previous Literature.*

The geological literature dealing with this district is extremely scanty. More than thirty years ago Mr. R. A. F. Murray made a flying survey of this portion of Gippsland, and issued a report[1] which embodies most of our knowledge of the geology of the region. A sketch geological map was also prepared, embracing the country as far north as a line running east and west through Mt. Tamboritha. The whole of the Wellington valley, therefore, comes in in the northern portion of the sheet. Though some portions of the map require revision, it is nevertheless a most useful guide to travellers in this district. Lake Karng, at the foot of Mt. Wellington, was then unknown, and the district to the west of Mt. Wellington was not closely examined by Murray, hence he missed discovering a considerable inlier of upperordovician rocks, which are consequently not shown in his map. He, however, observed that this region would probably afford geological features of interest, for he had been informed of the occurrence of serpentine and chrome-iron ore in that locality.

The next geologist to make observations on the district was the late Dr. A. W. Howitt, who many years after Murray's ex-

1 R. A. F. Murray. Geological Sketch Map, No. 2, S.E. Gippsland; and report in Prog. Rep. Geol. Surv. Vic., No. V., p. 44.

R. A. F. Murray. Geology and Physical Geography of Victoria, 1895.

plorations, made several excursions to examine the small but interesting mountain lake, now known as Tali Karng, situated in an inaccessible mountain valley on the western flanks of Mt. Wellington. The lake was accidentally discovered in 1888 by a the lake in an account published in the Mining Department's stockman named Snowden, but the first authentic information was due to Howitt, who discussed the question of the origin of Reports, 1891.[1] The lake is due to a huge barrier, but Howitt was not able to satisfy himself as to whether the feature was to be attributed to a landslip or to a moraine. The ice origin, however, was the view most favoured.

No geological features of this district were described, but Snowy Bluff, in the Wonnangatta valley, and to the north of Wellington, was carefuly examined by both Murray and Howitt, who showed the importance and interest of the sections exposed on the slopes of this mountain. This area is better approached from the Wonnangatta side than from the Macallister valley. It was the interest attached to the origin of the lake which first attracted the present writer to the Wellington region. The first visit was made in January of 1905, and observations on the origin of the lake were published in the Victorian Naturalist of the same year.[2] The landslip origin of the lake is there upheld. During the tour, however, graptolite slates were noted on the Wellington river, and the fossils collected were reported on by Dr. T. S. Hall,[3] who showed that they represented the upper ordovician series, and the existence of a great inlier of lower palaeozoic rocks was thus established.

The serpentine and chromite mentioned by Murray were also found to occur close at hand, in the slate area. An interesting conglomerate, composed mainly of serpentine boulders in a matrix of the same kind, was found along the margin of the serpentine.

The peculiarities of this occurrence were briefly described by the writer, in a previous publication of this society.[4] The

1 Dr. A. W. Howitt. Notes on Lake Karng, Rep. Mining Department Vic., Sept. 1891 p. 28.

2 E. O. Thiele. A Trip to Lake Karng and Mt. Wellington, N. Gippsland; Victorian Naturalist, vol. xxii., 1905, p. 22.

3 T. S. Hall, M.A., D.Sc. Victorian Graptolites, part iii. From near Mt. Wellington; Proc. Roy. Soc. Victoria, n.s., vol. xviii., part i., 1905.

4 E. O. Thiele. On a Palaeozoic Serpentine Conglomerate, N. Gippsland; Proc. Roy. Soc. Victoria, n.s., vol. xviii., part i., 1905.

possibility of the glacial origin of the conglomerate was discussed, but the question was left an open one. Later observations suggest that the deposit is most likely due to ordinary aqueous agency, probably a shore line conglomerate. The scope for further enquiry, however, became evident, and opportunities to again visit the area were waited for. These were availed of two years later, when an extensive three weeks' exploration was planned into the heart of the little known region north of Wellington, including, on the return, an examination of the serpentine area. The somewhat travel-worn condition of the party on arrival at this locality after two weeks' rough travelling, together with depleted stores, somewhat lessened the opportunities relied on for working the serpentine area. A considerable quantity of material, however, was collected for chemical and petrological examination. A fossiliferous limestone was noted, containing an abundant brachiopod, identified by Mr. Chapman as *Platystrophia biforata*. The limestone was considered as representing the Yeringian division of the Silurian series. Stratigraphical evidence supporting this, however, was not available. More problems were really raised than were solved, so that in the following year a third visit was made. This time heavy rains and flooded rivers somewhat impeded observations, but as more time was available a good deal of additional information was collected. Fresh limestone outcrops were examined, and at one spot abundant but fragmentary trilobite remains were discovered. The relations of the jasperoid slates to the more normal graptolite slate was worked out, but the complete stratigraphical succession was rendered somewhat puzzling by the examination by Mr. Chapman of the trilobites from the limestone.

About the middle of last year (1907), the occurrence of massive corundum was reported from the serpentine area, and Mr. Dunn, Director of the Geological Survey, in company with Professor Skeats, of the Melbourne University, paid a flying visit to examine the occurrence, the first of its kind known in Victoria. Only a few days were available for geological observations, which were further limited by the roughness of the country. Both gentlemen, however, were impressed with the interest and complexity of the geology. An account of Mr. Dunn's observations appeared in the "Mining Standard," Oct.

16, 1907. The official report is not yet available. Last year some opportunity was afforded at the University for the chemical and petrological examination of some of the rocks and minerals collected. This was further supplemented by some valuable chemical analyses by Mr. G. Ampt, B.Sc., who formed one of the party on the 1907 trip. Mr. Ampt's analyses were conducted in the Chemical laboratory of Melbourne University This year, though time has been somewhat limited, some further petrological research has been carried out in the Geological laboratory, and considerable help has been afforded by Professor Skeats, whose personal knowledge of the district made his advice particularly valuable.

IV.—*The Serpentine Area.*

(a) Physiographical features:—

The lower palaeozoic area covers probably 40 or 50 square miles to the west of Mt. Wellington, and occupies the basin of the upper Wellington river. A large basin is here in process of formation. The crown of a great anticlinal fold of the overlying upper palaeozoic rocks has been denuded, exposing the underlying slates. These have yielded to denuding agencies more rapidly than the overlying sandstones and rhyolitic lavas, so that the slate region is marked by a great immature basin filled with lower, but still precipitous, hills, surrounded by an amphitheatre of high and imposing scarps of the upper palaeozoic rocks. The eastern wall rises particularly steeply to an elevation of over 5000ft., and is formed of a great pile of acid lavas of Mt. Wellington. The basin extends northwards to the east of Tamboritha, towards the headwaters of the Wellington, and southwards to a transverse east and west ridge joining the Avon and Macallister watersheds. The western wall is broken by the gorge through which the Wellington issues towards the Macallister.

The valleys are deeply incised into the slates, and are the characteristic narrow V-shaped mountain valleys, with very restricted alluvial flats.

Three important streams drain this basin, the upper Wellington and two tributaries. The central one is the Barrier Creek, which flows from the springs issuing at the base of the barrier of Lake Karng. The northern portion is drained by the head waters of the Wellington, while the Dolodrook drains the southern. The valley of the last named includes a minor basin of some comparatively open, clear country, where the serpentine follows the river, and it is to this district that attention is chiefly directed.

The direction and distribution of the original streams were undoubtedly impressed upon the country before the covering of upper palaeozoic rocks was removed, and was no doubt largely determined by structural features in these rocks, for the rectangular dissection which marks the drainage system of the upper palaeozoic belt can still be recognised in this area, somewhat modified, of course, by later action of the differently disposed lower palaeozoic rocks. It appears probable that this region represents a much enlarged and diverted portion of an old high-level, north-and-south strike valley, into which the lower Wellington advanced from the west, by headward erosion, and thus materially reinforced the denudation and dissection of the area. Remnants of such valleys are still preserved in other parts of the upper palaeozoic rocks at elevations of from 4000 to 5000 ft. above sea level. The soil throughout the area is generally poor, and vegetation, though abundant, is not luxuriant. On the hills the prevailing eucalypts are red and yellow box; grass is scanty, except in small patches on the ledges and saddles, generally where chocolate mudstones or basic lavas outcrop. The sandstone and rhyolite outcrops are generally rough and rocky. The snow-plains are covered in part with thick belts of stunted snow-gums, with occasional open and extended stretches, carpeted with thick snow-grass and mossy patches, from which abundant springs issue.

Thousands of cattle are annually driven up to these areas for summer grazing, and as no boundaries or lines have been fixed by the Lands Department, considerable difference of opinion frequently exists as to the rights of the various graziers who rent these rather valuable summer pastures.

On the low country the serpentine belt is in marked contrast to the surrounding slates, and is sharply delineated by the darker soil and richer grass. Unfortunately for the pastoral prospects of this district, the favoured soil area is of a very limited extent.

Undergrowth is very scanty, except along the river courses, and where bush fires have swept the hills clear of growth, the bare rubbly slate surface shows striking evidences of extremely rapid gravitation under the influence of rain storms.

(b) *General Geology of the Lower Palaeozoic Area.*

The following rocks require special attention:—

1. Serpentine and associated rocks and minerals.
2. Sediments composed largely of serpentine detritus.
3. Bluish grey crystalline and fossiliferous limestones.
4. Black jasperoid slates with network of small quartz veins.
5. Normal graptolite slates.

(1) Serpentine and Associated Rocks and Minerals.

The serpentine area consists of a narrow belt varying in width from about a quarter of a mile to about two chains, and extending a little over three miles in length. The most northerly outcrop is to be seen in the bed of the Dolodrook river, at the mouth of Black-Soil Gully. Here the outcrop is about two chains wide, and lies between black jasperoid slate on the north-east side, and black slate with bluish calcareous bands on the south-west. The strike of the slate is the normal one throughout the area, being approximately north-west. The dip is at a high angle, and apparently to the north-east. but the rocks are contorted, and satisfactory observations could not be obtained. The serpentine is much decomposed here, and it is not clear whether it represents the original rock in situ, or compacted serpentine detritus, such as is found elsewhere interbedded in the lower palaeozoic sediments.

Travelling in a south-easterly direction up Black-Soil Gully to its head, no more serpentine is seen till the head of the gully is reached. for the underlying rocks are concealed beneath a considerable thickness of black soil. full of black slate fragments, but largely derived from the serpentine rocks higher up. The only rock outcrop noted was where the detritus had been washed out of the bed of the gully, exposing the jasperoid slates. These rocks outcrop also on either side of the valley. The serpentine is again exposed in the saddle at the head of the gully, known as the Monument Gap, and it can be traced thence continuously south-east for about three miles. It descends to the Dolodrook river, which it crosses just above its junction with Thiele's Creek. This stream has been so named by local bushmen, and its name perpetuated by Mr. Dunn. Beyond this junction the serpentine continues on the south side of the Dolodrook for a distance of about one mile, widening out to form a patch of open, park-like country, about a quarter of a mile in width, and well covered with good kangaroo grass. Returning to the Monument end, a number of features of interest present themselves. The serpentine in general is much crushed and foliated, and the general strike of the foliation planes is north-west, in conformity with the strike of the slates. Evidence of some shearing and considerable crushing is to be seen throughout the rocks.

The schistose edges of the outcropping rocks are prominent in some parts, and project here and there in a characteristic knife-like manner. A small pinnacle about 12 ft. high is known as the Monument, and from its vicinity a grand and imposing view is obtained eastwards to the precipitous cliffs and table top of Wellington, and westwards down the deep valley of the Wellington river to the rock-ledged summit of the "Crinoline." Last December (1907) the view was rendered particularly striking and charming by a heavy fall of snow, which brought out an infiinite number of rock structures as the snow lay in the crevices and depressions on the mountains.

Several types of serpentine are to be found, partly due to different stages in the alteration of the original igneous rock, and also to the character of this rock. A dark green to black, even-grained serpentine with a tendency to a slight mottled character, is fairly common. Microscopic sections show that the original rock was rich in olivine, and probably a peridotite. A further stage in oxidation shows a greener base with numerous red spots, forming rather an attractive rock when polished. Such a rock occurs in Roan-Horse Gully. An analysis of the dark variety, by Mr. Ampt, is given:—

SERPENTINE, DOLODROOK AREA.

Silica - - - -	38.43
Alumina - - -	3.08
Ferric oxide - - -	.37

Ferrous oxide	6.40
Magnesia	35.08
Soda	.77
Potash	.37
Water combined	13.58
Water hygroscopic	1.35
Chromic oxide	.16
Manganese	.12
Copper oxide	.06
Nickel oxide	.38
	100.15

Density - 2.80

Numerous boulders lie scattered about on the grassy slopes of the serpentine belt; some are waterworn, and evidently have weathered out of a serpentine conglomerate, to be referred to later. Other blocks, however, are irregular, and appear to represent portions of the original basic rock of the serpentine. Considerable variety is exhibited by these rocks. Most of them are tough pyroxene rocks, showing varying stages of alteration. One type common in the vicinity of the Monument Gap is a coarse-grained rock, extremely tough, and composed largely of a green, rhombic pyroxene, corresponding most closely to bronzite. About a third of the rock, however, consists of a hard, white mineral generally somewhat opaque. It is perhaps a secondary felspar, and parts of freshest sections show traces of the repeated twinning of the original triclinic felspar.

An analysis of this rock by Mr. Ampt is given:—

Silica	51.87
Alumina	5.28
Ferric oxide	2.29
Ferrous oxide	7.37
Lime	8.71
Magnesia	22.52
Soda	.47
Potash	.31
Water combined	.97
Water hygroscopic	.17
Chromic oxide	.21
Manganese	.10

Nickel - - -	.21
Copper - - -	.06
Titanium diox. - -	tr.
Phosphoric anhyd. -	tr.
	100.54

Density - 3.222

Another type varies from a creamish white through violet-grey to a light-green, coarse-grained rock. This rock consists almost entirely of monoclinic pyroxene, partly diallage, and some interstitial talcose mineral and serpentine. It is difficult to determine the limits of these rocks, and often, also, to decide whether the rock is in situ or not.

A spur descending from a point near the top of the Kangaroo Spur southwards to the Dolodrook River to a point above the junction of Thiele's Creek, shows a number of outcrops of the monoclinic pyroxene rocks, which are most probably in situ. Thin sections of these rocks frequently show considerable granulation and deformation of the constituents, indicating the intensity of the pressure to which the rocks have been subjected. Occasional foreign fragments have been noted in the slides, and have been no doubt picked up by the magma.

An analysis of a creamish-white rock, representing a somewhat altered type of the monoclinic pyroxene rocks, with some interstitial talcose mineral, is also due to Mr. Ampt.

Silica - - - -	36.36
Alumina - - -	18.54
Ferric oxide - - -	4.18
Ferrous oxide - -	1.15
Lime - - - -	23.44
Magnesia - - -	8.29
Soda - - - -	.68
Potash - - -	.25
Water combined - -	5.97
Water hygroscopic -	.82
Titanium dioxide - -	.62
Phosphoric anhyd. -	tr.
Chromic oxide - -	tr.
	100.30

Density - 3.237

One feature worthy of note can be observed in several places, notably a few chains west of the corundum outcrop on Kangaroo Spur, and again in a small gully to the west of the chromite occurrence, and that is the character of the dark greenish-black peridotite serpentine. At both these spots the appearance suggests an agglomerate, but more investigation is required to decide whether this is the case or whether the features are simply due to a particular type of weathering, simulating the fragmental character of an agglomerate.

Special Minerals.

The following require particular attention:—

(1) Corundum.
(2) Chromite.
(3) Common Opal.

(1) Corundum.—This was first found about the middle of last year by two bushmen, Macfarlane and Piden. Specimens were sent to the Mines Department, and also to the writer. The occurrence at once attracted the attention of Mr. Dunn, Director of Geological Survey, hence the flying visit by Mr. Dunn and Professor Skeats.

The corundum was found to occur sporadically in lumps up to about 3 cwt. in size, at two spots not far distant, namely, the Monument Gap and a little to the east, on the Kangaroo Spur, as indicated on the map. The mineral is violet in colour, somewhat translucent, compact and massive, rather tough, and breaking with a somewhat splintery fracture. A certain amount of a green amorphous mineral is present in small quantity, as impurity. This is probably a hydrated silicate of alumina, coloured with oxide of chromium.

Thin sections show the corundum as irregular patches of a violet colour, with numerous long prisms of the same mineral, forming a somewhat mesh-like appearance. Pleochroism is distinct. A small amount of interstitial material shows low polarization colours, and as the analysis shows very little magnesia it is probably some form of hydrated silicate of alumina.

A massive corundum has since been found in the Heathcote area by Professor Skeats, and a slide of this shows somewhat similar characters, with the exception that the interstitial mineral shows higher polarization colours. Both slides suggest that the corundum is original, and not secondary.

Through the courtesy of Mr. Dunn I am able to give an analysis of a sample of the Wellington Corundum, made in the Mines Department Laboratory.

SiO_2 - - - -	3.90
Al_2O_3 - - - -	85.11
Fe_2O_3 - - - -	0.42
FeO - - - -	0.41
MgO - - - -	0.15
CaO - - - -	0.46
Na_2O - - - -	0.26
K_2O - - - -	0.23
H_2O + above 110 -	7.03
H_2O − below 110 -	0.07
CO_2 - - - -	nil
TiO_2 - - - -	1.05
P_2O_5 - - - -	nil
Cr_2O_3 - - - -	1.40
MnO - - - -	nil
CrO - - - -	nil
SO_3 - - - -	nil
Cl - - - -	nil
	100.07

Density - 3.580

An analysis by the writer of a somewhat purer sample containing less of the green mineral was, unfortunately, not completed.

It indicated less than 0.5 per cent. SiO_2, nearly 90 per cent. Al_2O_3, and only a trace of CaO and MgO.

(2) Chromite has long been known to exist in this area, but on account of the inaccessibility of the district, little exploratory work has been done. A few shallow holes have been sunk, exposing a few lenticular blocks up to several hundredweight in size.

Both microscopic and chemical investigation of the serpentine shows the presence of the mineral in small amount throughout the area. The following analysis was made by Mr. Ampt.

SiO_2 - - - -	6.60
Al_2O_3 - - - -	16.34
Fe_2O_3 - - - -	5.20
FeO - - - -	8.62
CaO - - - -	0.24
MgO - - - -	17.15
Water combined - -	1.22
Water hygroscopic -	0.37
CoO - - - -	0.12
MaO - - - -	tr.
TiO_2 - - - -	tr.
P_2O_5 - - - -	tr.
Cr_2O_3 - - - -	45.03
	100.89

Density - 3.881

The question of the genesis of the corundum and the chromite can be conveniently discussed together, for the association in the Dolodrook district suggests analogies to similar occurrences elsewhere. In North America, corundum is known both in acid and in basic rocks. The latter occurrence is worthy of comparison. In North Carolina it is found near the margin of peridotite rocks, in which chromite also occurs, and J. H. Pratt, who has studied the occurrence, considers that the origin is best referred to as one of magmatic segregation. Morozewicz further showed experimentally that alumina is soluble in a molten, basic glass, and that on cooling the alumina rich magma crystals of corundum crystallized out.

No excavations have been made in the Dolodrook area to determine whether the corundum is in situ or not, but there is little reason to suspect that it is not, and Professor Skeats tells me that he has found it and chromite distributed in small quantities through the rocks of the Heathcote area, in which he has found the larger pieces of corundum. Chromite is recognised both as a secondary and an original constituent of igneous rocks, but it would appear the Dolodrook occurrence most probably indicates a particularly fine example of magmatic segregation, in which the olivine, pyroxenes, corundum and chromite all represent different phases.

The common opal is present only in small quantity, and of no particular interest. It is clearly secondary. The age of the serpentine will be referred to later.

(2) Sediments Composed Largely of Serpentine Detritus.

These deposits vary from coarse or waterworn conglomerates to fine-grained, hard banded rocks.

The conglomerate has been referred to in a previous paper. It can be examined at two outcrops, namely, at the Monument Gap and in the bed of the Dolodrook River, above Thiele's Creek junction.

In both places it lies along the south-western margin of the serpentine belt. At the Monument Gap, both the boulders and the matrix consist almost entirely of serpentine. Mechanical deformation and differential movement have squeezed and striated the boulders, but the evidence of aqueous origin appears to be still fairly pronounced.

In the bed of the Dolodrook, however, some finer beds are associated, containing some rounded and sub-angular fragments of a compact black rock suggesting at first sight black slate, but microscopic evidence shows this rock is a fine-grained, igneous one, and the matrix consists of serpentine and numerous fragments of pyroxene.

These beds dip westerly at a high angle, and overlie the coarser conglomerate which flanks the serpentine. A little further west, lower down the Dolodrook, the black graptolite slates form a bluff. The relation to the detrital serpentine rocks is not clear, but they appear to overlie them, which is in conformity with observations in other parts. In Roan-Horse Gully, east of the chromite occurrence, the fragmental beds are again exposed, and here portions show considerable calcification, some portions being of the nature of ophicalcite. An analysis of this material was made by Mr. Ampt.

Carbonate of Lime -	44.09
Silica - - - -	24.70
Alumina - - -	4.22
Ferric oxide - - -	.75
Ferrous oxide - -	5.36
Lime - - - -	3.99

Magnesia - - -	11.75
Soda - - - -	.22
Potash - - -	.20
Water combined - -	3.54
Water hygroscopic -	.53
Chromic oxide - -	.23
Manganese - - -	.07
Nickel - - -	.19
Copper - - -	.05
Strontia - - -	.03
Titanium dioxide - -	.19
	100.11

Density - 2.827

Close to Garvey's Hut, on the opposite side of the Dolodrook, fine-grained fragmental rocks, composed of igneous minerals, occur, They are stratified, but weather into long slender boulders, showing a marked spheroidal weathering. Here again microscopic evidence shows that they are composed of fragments of pyroxene and serpentine, but it is not clear whether they are sub-aqueous tuffs or normal sediments. These beds overlie the trilobite limestone a short distance down the stream, and are so closely associated with graptolite slates that it appears impossible to separate them.

(3) The Limestones.

These rocks occur as a number of small lenticular outcrops along a line conforming in general to the strike of the ordovician rocks, and a short distance away from the serpentine belt, on its south-western side. The most southerly outcrop is south of the chromite occurrence, close to Roan-Horse Gully. Here, as is the general case in this district, the rock is a hard bluish-grey crystalline limestone. A brachiopod identified by Mr. Chapman as *Platystrophia biforata*, is abundant in this outcrop, and as this fossil is known to Mr. Chapman in other Victorian limestones, which he regards as Yeringian (Silurian), he considered this limestone to belong also to this series.

Since this decision, however, trilobites have been found at the other end of the limestone belt, and these fossils open up very interesting questions with regard to the age of the limestone. The specimens identified show such an extremely remarkable association of genera that better preserved material is urgently required before safe conclusions can be drawn. At present, however, it can be stated that on stratigraphical evidence one would be strongly inclined to group the limestone with the Upper Ordovician slates.

(4) The Jasperoid Slates.

These rocks are well exposed in several places, notably on the Dolodrook River, below Garvey's Hut, as shown on the map, and again on a spur to the south of the same hut.

Until last January the age of these rocks had not been fixed, and as it seemed to be a growing custom to consider all black jasperoid and cherty rocks in the Lower Palaeozoic areas of Victoria as Heathcotian, it was advisable to test the case in the Dolodrook area.

Careful search in this district showed clearly that here these rocks must be grouped with the normal black slates of Upper Ordovician age, for the characteristic graptolites were found throughout the series, and highly silicified bands were found clearly interbedded with the normal slates.

Thin sections of various grades of the indurated slates showed fine examples of various stages in the silicification. All showed evidence of extreme pressure developing a schistose structure marked by undulating lines, too black and dense to be determined, but containing a minute micaceous mineral. Abundant lenticles of secondary quartz and chalcedony make up the greater part of the rock.

(6) The Graptolite Slates.

There is now really no need to separate these from the jasperoid slates. They are all one series, exhibiting different degrees of induration and silicification. They form the prevailing rock surrounding the serpentine belt, and afford graptolites in numerous localities. These fossils have been described in a paper by Dr. T. S. Hall. Many outcrops show intense contortion and crumpling, so that observations of dips are generally not of much use. Thin sections failed to show what was the nature of the original rocks from which they were derived.

(7) The Succession of the Rocks.

This cannot be said to be established yet, but considerable evidence has been collected since Mr. Dunn's hurried visit. This observer admitted that his ideas were only tentative. Two features largely influenced Mr. Dunn's reasoning:—

(1) The consideration of the limestone as Upper Silurian on Mr. Chapman's identification of the *Platystrophia*. The trilobite had not then been found.

(2) The interpretation of the black fragments in the conglomerate as black slate, and probably, therefore, indicating a post-Ordovician deposit.

An older age for the limestone now seems more reasonable, and the argument of the black fragments does not hold, since they are not slate, but fragments of a black igneous rock, as shown by thin sections. Mr. Dunn regarded the Ordovician as the oldest rock, the serpentine, or rather the original pyroxene rocks, as intrusive into the Ordovician slates, while the fragmental serpentinous rocks and limestones were grouped as Upper Silurian. The succession, however, which appears more correct to the writer, would place the massive serpentine and allied rocks as the oldest series—at least pre-Upper Ordovician; next, perhaps, the fragmental serpentine conglomerates, etc., limestones and slates. Further fossil evidence is necessary to determine whether further sub-division is necessary, but at present the course most in conformity with stratigraphical evidence is to consider the whole of the post-massive-serpentine series as Upper Ordovician.

V.—*The Rhyolites and Associated Rocks of the Upper Palaeozoic Series.*

As the writer has no time at present to do justice to the information collected on these rocks, they will be included simply to render available some analyses which were made last year in the University laboratory. The lavas include both acid and basic ones, the former largely predominating. They show an infinite variety of texture and colour, but chemically all are closely similar.

The commoner varieties show a base varying in colour from light green to pink and dark chocolate-brown. Phenocrysts consist of quartz and orthoclase felspar, the latter varying from white to pink.

One type from the western slopes of Wellington, in the vicinity of Lake Karng, is an attractive rock with a light greenish base and moderate sized phenocrysts, of white orthoclase and quartz. Thin sections show a fine perlitic structure.

In general from a structural point of view two divisions can be made:—

(1) Those showing marked flow structure.

(2) Those of the type of normal quartz porphyries.

Thin sections of the latter often show the phenocrysts embayed by the devitrified magma, but occasionally sections show no such features, and sharp, angular fragments of quartz and felspar form a granular base, suggesting a pyroclastic origin, but this feature is hard to establish. These rocks are of great extent and thickness, and their relation and distribution has been briefly referred to in a former paper.

	Banded Rhyolite, southern plateau of Wellington	Quartz porphyry, southern shore of Lake Karng. Dark greenish base, with phenocrysts of pink orthoclase.
SiO_2	78.64	78.47
Al_2O_3	9.85	10.68
TiO_2	0.67	0.59
Fe_2O_3	0.54	0.18
FeO	2.00	2.23
MgO	0.10	tr.
CaO	0.80	0.66
Na_2O	2.03	3.29
K_2O	5.16	4.15
P_2O_5	tr.	tr.
Water combined	0.40	0.2
Water hygroscopic	0.14	0.09
	100.33	100.54

Tho Basalts (Melaphyres of Howitt) belong to the upper palaeozoic series, and are frequently much altered. They frequently contain geodes and amygdales of chalcedony. Epidote and calcite are abundant as alterations products.

	Moroka Snow-plain—fairly fresh sample. By Mr. Ampt.	Bad Spur, Moroka Valley—rather altered specimen.
SiO_2	49.35	43.88
Al_2O_3	17.61	16.58
Fe_2O_3	1.50	5.53
FeO	9.72	9.11
CaO	7.71	9.60
MgO	3.17	5.77
Na_2O	3.10	2.02
K_2O	1.56	1.06
P_2O_5	tr.	tr.
Water combined	2.56	2.22
Water hygroscopic	0.65	0.64
TiO_2	2.83	3.52
MnO	0.07	tr.
Pyrite FeS_2	0.34	
	100.17	99.93
Density	2.918	

In conclusion, I desire to express my indebtedness to Professor Skeats, Dr. T. S. Hall, Mr. F. Chapman, F.L.S., Mr. H. J. Grayson, Mr. G. Ampt, B.Sc., and Mr. E. J. Dunn for help in collecting information on this area. At the same time I must offer apologies for the fragmental character and numerous shortcomings of this paper, due to extremely hurried compilation from notes, and to its being written under rather unfavourable conditions on the steamer between Melbourne and Adelaide.

APPENDIX.

Preliminary Notes on a Collection of Trilobite Remains from the Dolodrook River, N. Gippsland.

By FREDERICK CHAPMAN, A.L.S., &c.

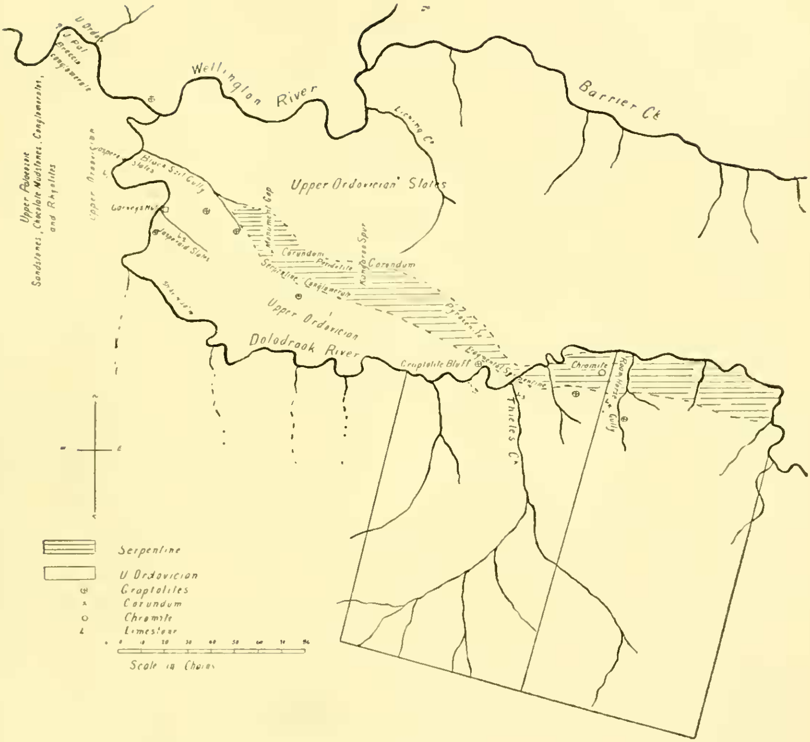
(National Museum.)

The following notes are based on some fragmentary fossils, all trilobitic, which Mr. E. O. Thiele, B.Sc., late of the Victorian Geological Survey, and now on the staff of the Imperial Institute, London, discovered in a bed of dark bluish limestone associated with Upper Ordovician slates at the Dolodrook River, Mt. Wellington District, N. Gippsland. Mr. Thiele has kindly placed the material in my hands for description, and, although the fossils are far from perfect, it seems advisable to publish the following brief notes upon them, with a view to affording some information as to the age of this limestone, which comes from a district of which the geology is still far from being fully known.

The limestone in which the fossils are found is hard and subcrystalline, and the method of its fracture does not entirely favour the extraction of the fossils. Moreover, the trilobites themselves have become disjointed, especially in the thoracic region, in most cases before being covered with sediment, since no examples of the pleura were seen, except the merest fragments.

The generic forms present belong to *Agnostus* and *?Proetus*, whilst a doubtful type, perhaps referable to *Cheirurus*, is represented by two imperfect tail-shields.

Agnostus sp. nov. Of this form both head and tail-shields are present. It is a member of the group Longifrontes, the distinguishing characters of the prominent glabella and the impressed line separating the anterior part of the cheeks and the lateral lobes of the tail behind the axis, being well marked. In general


Wellington River
Barrier Ck
Upper Ordovician Slates
Upper Ordovician
Dolodrook River
Thiele's Ck
Corundum
Serpentine
Graptolite Bluff
Chromite
Upper Palaeozoic
Sandstones, Chocolate Mudstones, Conglomerates, and Rhyolites
Serpentine
U Ordovician
Graptolites
Corundum
Chromite
Limestone
Scale in Chains